pressure is 3.0 atmosphere.

5. The rotation of the whetstone 32 is approximately 50,000 rpm which is the limiting case of the bearing, when the air pressure is 4.0 atmosphere.

Effect of Invention

The present invention of the piezoelectric element has the following effects.

1. High frequency quartz oscillators for example, which have an excellent electrical characteristics, become possible to be manufactured from the quartz blank by the conventional dual-face lapping machine, single-face lapping machine or float polishing machine.

2. The present invention enables the single inverted mesa type shape to be the plano-convex type. Also the electrical performance of the double inverted mesa type shows same improvement as the single inverted mesa type.

3. The quartz oscillator over 334 MHz becomes available when the aperture ratio of the diameter to the depth is approximately 80.

As mentioned above, the present invention makes the piezoelectric element to be extremely thin as less than 10 μm and to show practically no spurious signals.

Industrial Applicability

The present invention can be applied to a wide variety of fundamental oscillation sources for communication instruments and detection instruments, and micro clock generators for general computers, OA information technology and other instrumentations.

CLAIMS

1. An arbitrary shape piezoelectric element comprising a planer concave part at one central oscillating surface and a convex-lens-shape convex part at another central surface.

2. An arbitrary shape piezoelectric element comprising a concave-lens-shape concave part at one central oscillating surface and a convex-lens-shape convex part at another central surface.

3. An arbitrary shape piezoelectric element comprising a convex-lens-shape concave part at one central oscillating surface and a convex-lens-shape convex part at another central surface.

4. An arbitrary shape piezoelectric element comprising a concave-lens-shape

concave part at one central oscillating surface and a convex-lens-shape concave part at another central surface.

5. An arbitrary shape piezoelectric element comprising a convex-lens-shape concave part at one central oscillating surface and a plane-lens-shape concave part at another central surface.

6. An arbitrary shape piezoelectric element comprising a convex-lens-shape concave part at one central oscillating surface and a convex-lens-shape concave part at another central surface.

7. Manufacturing method for a piezoelectric element featuring the mechanical dual-face lapping of said piezoelectric blank and the polishing of said surface small roughness due to the chemical etching, after one surface or both surfaces of said piezoelectric element which are machined by the mechanical lapping process are chemically etched and become thinner.

8. Manufacturing method for said extremely thin piezoelectric element featuring the manufacturing process of said element by forming grooves and steps on the upper surface of the first auxiliary lapping tool, by connecting the second auxiliary lapping tool which is slightly higher than the depth of said grooves or steps into the grooves or steps of said first auxiliary lapping tool, by setting said piezoelectric blank on the upper surface of said first auxiliary lapping tool inside said second auxiliary lapping tool, and by lapping said blank with the upper lapping plate on said piezoelectric blank and with the lower lapping plate under said auxiliary lapping tool.

9. Manufacturing method for said piezoelectric element as in claim 8 featuring the process of filling liquid in said grooves or steps on said first auxiliary lapping tool surface, setting said piezoelectric blank so as to contact the lower surface of said piezoelectric blank to said liquid, and fixing said blank to said first auxiliary lapping tool by said liquid surface tension or by freezing.

10. Manufacturing method for said piezoelectric element as in claim 9 featuring to set said piezoelectric blank on a thin wet plate with water, and fixing said blank to said first auxiliary lapping tool by using said water surface tension of said thin wet plate.

11. Manufacturing method for said piezoelectric element as in claim 8 featuring making plural holes on said first auxiliary lapping tool, filling viscous material as adhesive into said holes, and fixing said blank to said first auxiliary lapping tool by connecting the lower surface of said piezoelectric

blank to said viscous material or by vacuum force.

12. Manufacturing method for said piezoelectric element as in claim 8 featuring to fix said blank to said first auxiliary lapping tool by using pine resin, paraffin, starch paste or other adhesives.

13. Manufacturing method for said piezoelectric element as in any of claim 8 to 12 featuring to use hard glass or metal as super steel as material of said first auxiliary lapping tool, and to use super steel, iron, hard glass or other glasses as material of said second auxiliary lapping tool.

14. Manufacturing method for said piezoelectric element featuring to make a concave part by chemical etching on one surface of said piezoelectric blank, to make thin the base surface of said concave side by ion etching of the opposite surface of said concave side, to lap mechanically both surfaces of said piezoelectric blank, to eliminate the roughness due to said ion etching process, and to form convex-lens shape oscillating part in said concave part.

15. Manufacturing method for said piezoelectric element of the previous claim 14 featuring to make a concave part by RIE process, ion milling plasma etching or other wet etching means only on the central part, after masking said piezoelectric blank one surface by the mask.

16. Manufacturing method for said piezoelectric element featuring to hold said piezoelectric blank on said auxiliary tool, to lap one surface of said piezoelectric blank by one lapping surface of said dual-face lapping machine, to lap at the same time one surface of said auxiliary tool by another lapping surface, and to use said dual-face machine as a single face lapping tool.

17. Manufacturing method for said piezoelectric element featuring to hold the front surface or the rear surface of said piezoelectric blank by said auxiliary lapping tool, and to lap the concave surface of said piezoelectric blank by one lapping surface, and at the same time one surface of said auxiliary lapping tool by another lapping surface of dual-face lapping machine

18. Manufacturing method for said extremely thin piezoelectric element featuring to make the concave part on said piezoelectric blank, to hold said concave part by said auxiliary lapping tool, and to lap the opposite surface of said concave part by one lapping surface and at the same time one surface of said auxiliary lapping tool by another lapping surface by using said dual-face lapping machine.

19. Manufacturing method for said extremely thin piezoelectric element featuring to lap said piezoelectric blank, which surface is concave,

concavo-convex or bi-convex, at the same time from the upper side and lower side by using said dual-face lapping machine.

20. Manufacturing method for said piezoelectric element as in claim 19 featuring to fill pine resin, paraffin or other adhesives into the concave pit of said concave piezoelectric blank, and to lap said reinforced concave blank.

21. Manufacturing method for said piezoelectric element as in any of claim 16 to 18 featuring to make said auxiliary lapping from hard glass, plastics or metal as super steel or iron, which is hardly lapped by said lapping material as selenium oxide etc, and not easy to lap the one surface of said auxiliary lapping tool.

22. Manufacturing method for said piezoelectric element, as in claim 14, featuring to make the concave part on said piezoelectric blank, after setting the masking plate of holed quartzite on the piezoelectric blank and making the ion etching machining by using the masking technique.

23. Manufacturing method for said piezoelectric element, as in claim 14, featuring to higher the surface lapping accuracy of quartz and so on by using Argon mixed with fluorine gas as CF4, CHF3 or C2H8 etc, when the piezoelectric material as quartz and so forth is ion-etched.

24. Manufacturing method for said piezoelectric element, featuring to make electrodes to impress the electric voltage on the piezoelectric element after connecting fine gold wires to the central part of said piezoelectric plate.

25. Manufacturing method for very thin piezoelectric element, featuring to make the concave part on said piezoelectric blank, after lapping at the same time both surfaces of said piezoelectric blank, which one surface is flat and another side is concave, by using said dual-face lapping machine.

26. Manufacturing method for said piezoelectric element featuring to lap at the same time both surfaces of said piezoelectric blank, which one surface is stil flat and another side is concave, by using said dual-face lapping machine, and to make outer a convex lens shape of plano-convex, concavo-convex or bi-convex at the front side.

27. Manufacturing method for said piezoelectric element featuring to only to lap one surface of said piezoelectric blank by one surface of said dual-face lapping machine after putting said blank naturally on said auxiliary lapping tool made from metal or other material or pasting said blank by adhesives as pine resin, paraffin or others, and also to lap the rear surface of said auxiliary lapping tool by anther surface, and to make plano-convex type, concavo-convex type or

bi-convex type by lapping the rear surface of said blank.

28. Manufacturing method for said piezoelectric element featuring to only to put said concave piezoelectric blank on said auxiliary lapping tool with vertical holes, or to paste by adhesives as pine resin or paraffin etc., and to lap one surface of said dual-face lapping machine after putting said blank naturally on said auxiliary lapping tool made from metal or other material, and also to lap the rear surface of said auxiliary lapping tool by anther surface, and to make plano-convex type, concavo-convex type or bi-convex type by lapping the rear surface of said blank.

29. Manufacturing method for said piezoelectric element featuring to lap the damaged layer, which is produced during the conventional wet etching and RIE processes, by mechanical lapping process, after said mechanically lapped piezoelectric blank is made to be extremely thin by said chemical and ion etchings.

30. Manufacturing method for said piezoelectric element, featuring to lap said blank so that one surface is in concave lens shape and another side is protruding as convex lens.

31. Manufacturing method for said piezoelectric element featuring that one surface is in concave lens shape and another side is protruding as convex lens which convex part is only made to be imminent from the flat plate.

32. Manufacturing method for said piezoelectric element featuring that the ratio of the diameter to the depth is from 10 to 350, or preferentially from 30 to 150 for said element.

33. Manufacturing method for said piezoelectric element, featuring to make the perpendicular and horizontal central lines unchanged to the tool holder for any diameters of diamond whetstone grains, by using the ball whetstone which diamond grains are not solely electrically gilt to the touching part of the tool holder, when the ball whetstone is set to the cylindrical tool holder by the magnetic induction of magnet in cylindrical shape etc of the primary axis.

34. Sound to electric converter, featuring to make pressure sensing surface of piezoelectric effect material at the central part and to set a pair of electrodes at said surface.

35. Sound to electric converter, as in claim 34, featuring to make pressure sensing surface of piezoelectric effect material together to the cylinder.

36. Sound to electric converter, as in claim 34 or 35, featuring to make the central pressure sensing surface vibrate intensively, after forming holes

or space at the circumferential part of the pressuring surface in order to resonate the air oscillation when the sound comes into both sides of the cylinder towards said pressuring surface.

37. Manufacturing method of sound to electric converter, featuring to make cylindrical hole into both sides of circular piezoelectric rod by milling method, to make the pressure sensing surface of required thickness at the center of said rod, and to set a pair of electrodes at the pressure outer surface in order to get the electric signal amplified from the environmental air oscillation.

38. Machining method of piezoelectric effect material, as in claim 37, featuring to make grains on the barrel surface of whetstone, to inject air or liquid to the grains, and rotate said whetstone, as the machining means, or to use other mechanical techniques.

39. Manufacturing method for said sound to electric converter, as in claims37 and 38, featuring to make barrel whetstone by using steel sphere in a genuine circular cross section.

40. Manufacturing system for said sound to electric converter, featuring no only to include the machine to fix one end of piezoelectric circular rod and to rotate around the rod axis line, but also to use the machining tool, of which end has the driving mechanism to rotate said whetstone in barrel shape in high speed.